ANALYSIS OF VARIANCE SET-UP FOR JOINT PROJECT 69

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Due to the many splits in the original experiment, the total analysis is somewhat complex and detailed. However, if one considers simplest items first, things are not so bad. The analysis for the part of the design consisting of 16 sulfur- and lime-treated plots on the first page of the field plan of the outline follows:

Table 1. Analysis of Variance of Main Treatments.

Source of Variation	Degrees of Freedom
Soils (cane land vs. pineapple land) -- S	1
Columns within S	1 + 1 = 2
Rows	3
Treatments on cane land -- TC	1
Treatments on pineapple land -- TP	1
Residual	7
Total	15

The arrows indicate the error terms for testing the various sources of variation.

Before proceeding, it is best to check the above analysis to see that it is correct. For this let us consider the individual degrees of freedom for the 15 individual comparisons after numbering the plots, thus:

Table 2. Numbering of large plots in cane and pineapple lands.

	Cane		Pineapple	
Row 1	1	2	3	4
Row 2	5	6	7	8
Row 3	9	10	11	12
Row 4	13	14	15	16
Column	1	2	3	4

Table 3. A Set of Fifteen Orthogonal Comparisons.

	Comparison	Plot Number															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	S	+	+	-	-	+	+	-	-	+	+	-	-	+	+	-	-
2	Cols. in Cane	+	-			+	-			+	-			+	-		
3	Cols.in Pineapple			+	-			+	-			+	-			+	-
4	C vs. A (in Cane)	+	-			-	+			+	-			-	+		
5	L vs. P (in Pineapple)			+	-			-	+			+	-			-	+
6	C vs. C (in Col. 1)	+								-							
7	C vs. C (in Col. 2)						+								-		
8	A vs. A (in Col. 1)					+								-			
9	A vs. A (in Col. 2)		+								-						
10	L vs. L (in Col. 3)			+								-					
11	L vs. L (in Col. 4)								+								-
12	P vs. P (in Col. 3)							+								-	
13	P vs. P (in Col. 4)				+								-				
14	Treatment x Cols. in Cane	+	+			-	-			+	+			-	-		
15	Treatment x Cols. in Pineapple			+	+			-	-			+	+			-	-

C and P = Untreated Cane and Pineapple lands, respectively;
A and L = Treated Cane and Pineapple lands, respectively;
S = Cane vs. Pineapple Soil.

For the above set-up the analysis of variance is shown on the following page.

Table 4. Analysis of Variance of Main Treatments.

Source of Variation	degrees of freedom
Soils (Comparison 1)	1
Columns within soils (Comparison 2 and 3)	2
Treatments on cane land (Comparison 4)	1
Treatments on pineapple land (Comparison 5)	1
Between duplicates for C (Comparison 6 and 7)	2
" " " A (" 8 " 9)	2
" " " L ((" 10 " 11)	2
" " " P (" 12 " 13)	2
Treatments x columns on cane land (Comparison 14)	1
" x " " pineapple land (Comparison 15)	1
Total	15

From Table 2 and Table 3, respectively, we see that the sum of comparisons 6, 9, 10, and 13 represents the comparison of row 1 versus row 3; that comparisons 7, 8, 11, and 12 represent the comparison of row 2 with row 4; and that comparisons 14 plus 15 represent the comparison of rows 1 and 3 with rows 2 and 4. Thus, the last 10 degrees of freedom in the above analysis (Table 4) may be partitioned as follows:

Source of Variation	degrees of freedom
Rows	3
Residual	7

The above is the breakdown given on page 1 of this report.

The complete analysis of variance breakdown for the design used in Joint Project 69 is:

Table 5. Complete Analysis of Variance for Joint Project 69.

Source of Variation	degrees of freedom
1. Soils (cane land vs. pineapple land) -- S	1
2. Columns within S [error (a')]	2
3. Rows	3
4. Treatments on cane land -- TC	1
5. Treatments on pineapple land -- TP	1
6. Residual	7
Sub-total	15
7. Preplant fumigation (Roman numerals I, II, III) -- F	2
8. F x Rows [error (a)]	6
9. F x S	2
10. F x Columns within S	4
11. F x TC	2
12. F x TP	2
13. F x Residual	14
Sub-total	32

	Source of Variation	degrees of freedom
14.	Postplant fumigation (Y vs. Z) -- E	1
15.	E x F	2
16.	E x Rows within F [error (b)]	9
17.	E x S	1
18.	E x Columns within S	2
19.	E x TC	1
20.	E x TP	1
21.	E x Residual	7
22.	E x F x S	2
23.	E x F x Columns within S	4
24.	E x F x TC	2
25.	E x F x TP	2
26.	E x F x Residual	14
	Sub-total	48
27.	Urea vs. Sulfate of ammonia (U vs. S) -- N	1
28.	N x E	1
29.	N x F	2
30.	N x F x E	2
31.	N x Rows within E and F [error (c)]	18
32.	N x S	1
33.	N x Columns within S	2
34.	N x TC	1
35.	N x TP	1
36.	N x Residual	7
37.	N x F x S	2
38.	N x F x Columns within S	4
39.	N x F x TC	2
40.	N x F x TP	2
41.	N x F x Residual	14
42.	N x E x S	1
43.	N x E x Columns within S	2
44.	N x E x TC	1
45.	N x E x TP	1
46.	N x E x Residual	7
47.	N x E x F x S	2
48.	N x E x F x Columns within S	4
49.	N x E x F x TC	2
50.	N x E x F x TP	2
51.	N x E x F x Residual	14
	Sub-total	96
52.	Minor elements -- Mi	1
53.	Mi x S	1
54.	Mi x Columns within S [error(b')]	2
55.	Mi x TC	1
56.	Mi x TP	1
57.	Mi x Residual	7
58.	Mi x F	2
59.	Mi x Rows within F	9

	Source of Variation	degrees of freedom
60.	Mi x F x S	2
61.	Mi x F x Columns within S	4
62.	Mi x F x TC	2
63.	Mi x F x TP	2
64.	Mi x F x Residual	14
65.	Mi x E	1
66.	Mi x E x F	2
67.	Mi x E x Rows within F	9
68.	Mi x E x S	1
69.	Mi x E x Columns within S	2
70.	Mi x E x TC	1
71.	Mi x E x T P	1
72.	Mi x E x Residual	7
73.	Mi x E x F x S	2
74.	Mi x E x F x Columns within S	4
75.	Mi x E x F x TC	2
76.	Mi x E x F x TP	2
77.	Mi x E x F x Residual	14
78.	Mi x N	1
79.	Mi x N x E	1
80.	Mi x N x F	2
81.	Mi x N x F x E	2
82.	Mi x N x Rows within E and F	18
83.	Mi x N x S	1
84.	Mi x N x Columns within S	2
85.	Mi x N x TC	1
86.	Mi x N x TP	1
87.	Mi x N x Residual	7
88.	Mi x N x F x S	2
89.	Mi x N x F x Columns within S	4
90.	Mi x N x F x TC	2
91.	Mi x N x F x TP	2
92.	Mi x N x F x Residual	14
93.	Mi x N x E x S	1
94.	Mi x N x E x Columns within S	2
95.	Mi x N x E x TC	1
96.	Mi x N x E x TP	1
97.	Mi x N x E x Residual	7
98.	Mi x N x E x F x S	2
99.	Mi x N x E x F x Columns within S	4
100.	Mi x N x E x F x TC	2
101.	Mi x N x E x F x TP	2
102.	Mi x N x E x F x Residual	14
	Sub-total	192
103.	Major elements -- Ma	1
104.	Ma x S	1
105.	Ma x Mi	1
106.	Ma x Mi x S	1
107.	Ma x Columns within Mi and S [error (c')]	4

	Source of Variation	degrees of freedom
108.	Ma x TC	1
109.	Ma x TP	1
110.	Ma x Residual	7
111.	Ma x F	2
112.	Ma x Rows within F	9
113.	Ma x F x S	2
114.	Ma x F x Columns within S	4
115.	Ma x F x TC	2
116.	Ma x F x TP	2
117.	Ma x F x Residual	14
118.	Ma x E	1
119.	Ma x E x F	2
120.	Ma x E x Rows within F	9
121.	Ma x E x S	1
122.	Ma x E x Columns within S	2
123.	Ma x E x TC	1
124.	Ma x E x TP	1
125.	Ma x E x Residual	7
126.	Ma x E x F x S	2
127.	Ma x E x F x Columns within S	4
128.	Ma x E x F x TC	2
129.	Ma x E x F x TP	2
130.	Ma x E x F x Residual	14
131.	Ma x N	1
132.	Ma x N x E	1
133.	Ma x N x F	2
134.	Ma x N x F x E	2
135.	Ma x N x Rows within E and F	18
136.	Ma x N x S	1
137.	Ma x N x Columns within S	2
138.	Ma x N x TC	1
139.	Ma x N x TP	1
140.	Ma x N x Residual	7
141.	Ma x N x F x S	2
142.	Ma x N x F x Columns within S	4
143.	Ma x N x F x TC	2
144.	Ma x N x F x TP	2
145.	Ma x N x F x Residual	14
146.	Ma x N x E x S	1
147.	Ma x N x E x Columns within S	2
148.	Ma x N x E x TC	1
149.	Ma x N x E x TP	1
150.	Ma x N x E x Residual	7
151.	Ma x N x E x F x S	2
152.	Ma x N x E x F x Columns within S	4
153.	Ma x N x E x F x TC	2
154.	Ma x N x E x F x TP	2
155.	Ma x N x E x F x Residual	14
156.	Ma x Mi x TC	1
157.	Ma x Mi x TP	1
158.	Ma x Mi x Residual	7

	Source of Variation	degrees of freedom
159.	Ma x Mi x F	2
160.	Ma x Mi x Rows within F	9
161.	Ma x Mi x F x S	2
162.	Ma x Mi x F x Columns within S	4
163.	Ma x Mi x F x TC	2
164.	Ma x Mi x F x TP	2
165.	Ma x Mi x F x Residual	14
166.	Ma x Mi x E	1
167.	Ma x Mi x E x F	2
168.	Ma x Mi x E x Rows within F	9
169.	Ma x Mi x E x S	1
170.	Ma x Mi x E x Columns within S	2
171.	Ma x Mi x E x TC	1
172.	Ma x Mi x E x TP	1
173.	Ma x Mi x E x Residual	7
174.	Ma x Mi x E x F x S	2
175.	Ma x Mi x E x F x Columns within S	4
176.	Ma x Mi x E x F x TC	2
177.	Ma x Mi x E x F x TP	2
178.	Ma x Mi x E x F x Residual	14
179.	Ma x Mi x N	1
180.	Ma x Mi x N x E	1
181.	Ma x Mi x N x F	2
182.	Ma x Mi x N x F x E	2
183.	Ma x Mi x N x Rows within E and F	18
184.	Ma x Mi x N x S	1
185.	Ma x Mi x N x Columns within S	2
186.	Ma x Mi x N x TC	1
187.	Ma x Mi x N x TP	1
188.	Ma x Mi x N x Residual	7
189.	Ma x Mi x N x F x S	2
190.	Ma x Mi x N x F x Columns within S	4
191.	Ma x Mi x N x F x TC	2
192.	Ma x Mi x N x F x TP	2
193.	Ma x Mi x N x F x Residual	14
194.	Ma x Mi x N x E x S	1
195.	Ma x Mi x N x E x Columns within S	2
196.	Ma x Mi x N x E x TC	1
197.	Ma x Mi x N x E x TP	1
198.	Ma x Mi x N x E x Residual	7
199.	Ma x Mi x N x E x F x S	2
200.	Ma x Mi x N x E x F x Columns within S	4
201.	Ma x Mi x N x E x F x TC	2
202.	Ma x Mi x N x E x F x TP	2
203.	Ma x Mi x N x E x F x Residual	14
	Sub-total	384
	Total	767

As a further aid in understanding the detailed analysis, consider the rows and only the treatments applied in strips in a row. The resulting design is a split-split-plot design with the following analysis of variance:

Source of Variation	degrees of freeddom
Rows	3
F	2
Error (a)	6
E	1
E x F	2
Error (b)	9
N	1
N x F	2
N x E	1
N x E x F	2
Error (c)	18
Total	47

Likewise, if we consider only the treatments applied in complete strips within a column we have a split-split-plot design (with a systematic arrangement of the treatments) with the following analysis of variance set-up:

Source of Variation	degrees of freedom
Soils -- S	1
Columns within soils error (a')	2
Mi	1
Mi x S	1
Error (b')	2
Ma	1
Ma x S	1
Ma x Mi	1
Ma x Mi x S	1
Error (c')	4
Total	15

Other simple breakdowns could be made which would be of the split block nature. These breakdowns are not presented.

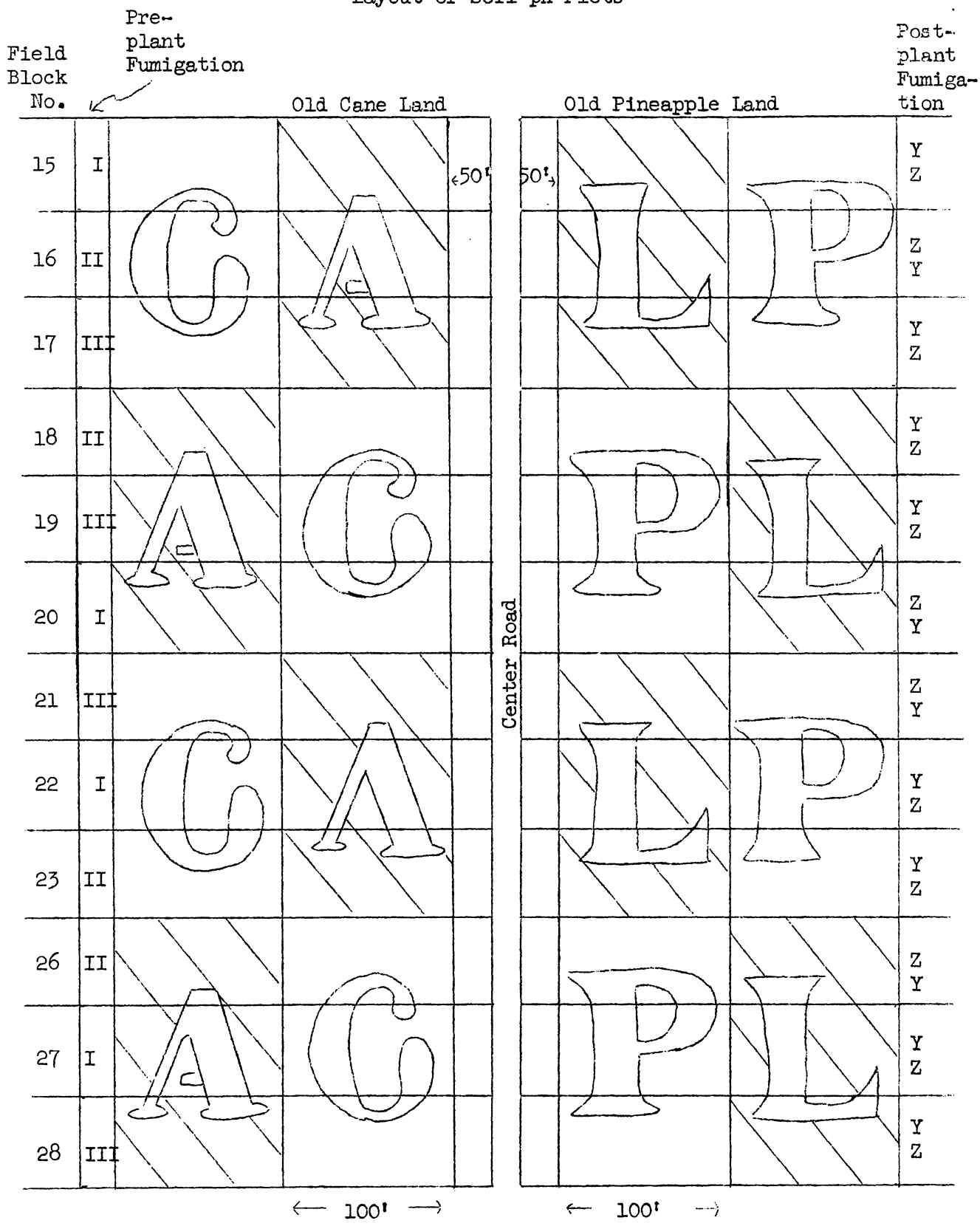
No attempt was made to pool various terms which might be considered as estimates of the same quantity. Also, it is questionable if the four and five factor interactions should be separated out since they probably

are nonexistent or small relative to the other effects. Some sources of variation which probably could be pooled are:

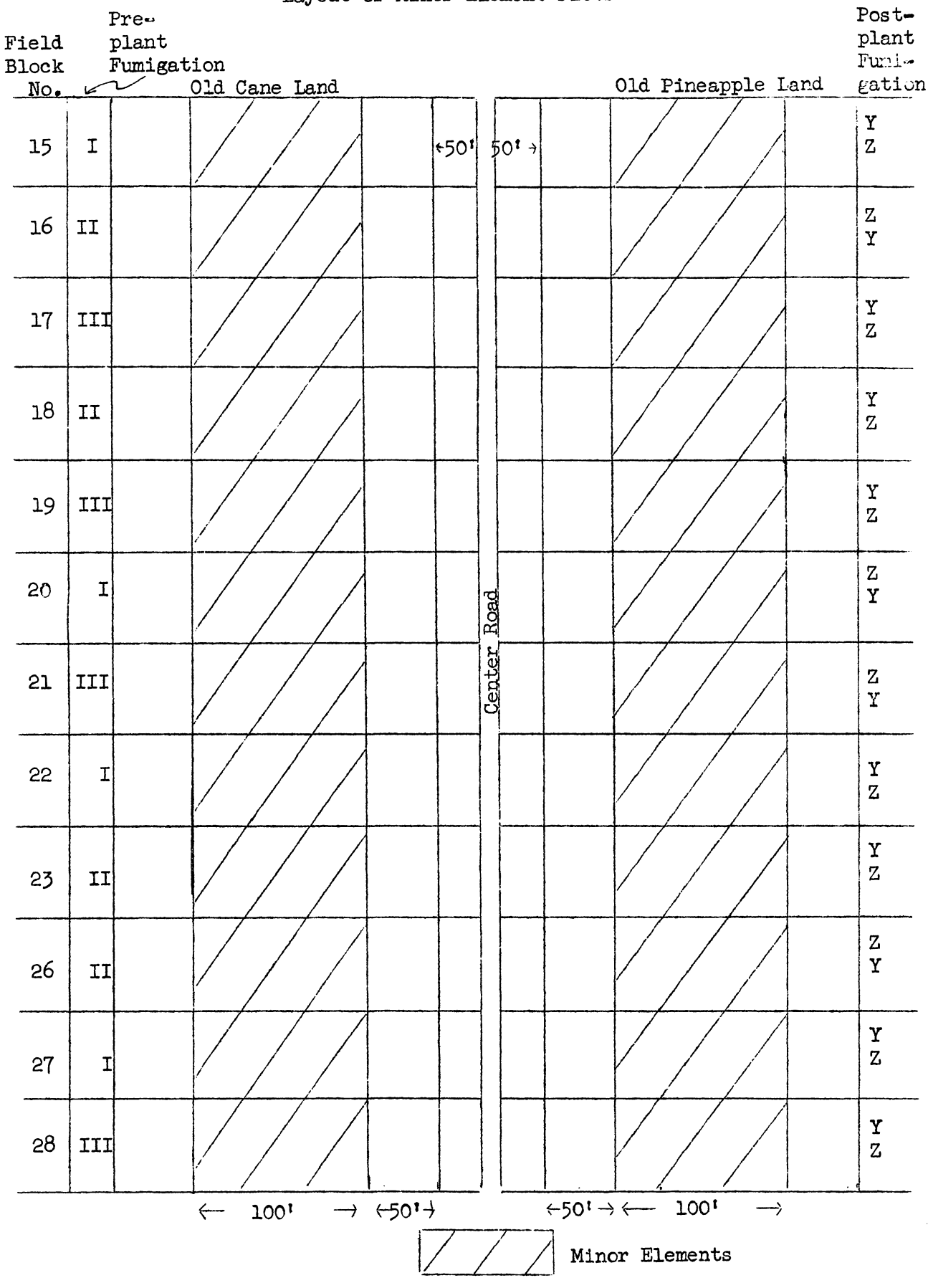
(i) 18 and 23
(ii) 21 and 26
(iii) 33, 38, 43, and 48
(iv) 36, 41, 46, and 51
(v) 61, 69, 74, 84, 89, 94, and 99
(vi) 57, 64, 72, 77, 87, 92, 97, and 102
(vii) 114, 122, 127, 137, 142, 147, 152, 162, 170, 175, 185, 190, 195, and 200
(viii) 110, 117, 125, 130, 140, 145, 150, 155, 158, 165, 173, 178, 188, 193, 198, and 203

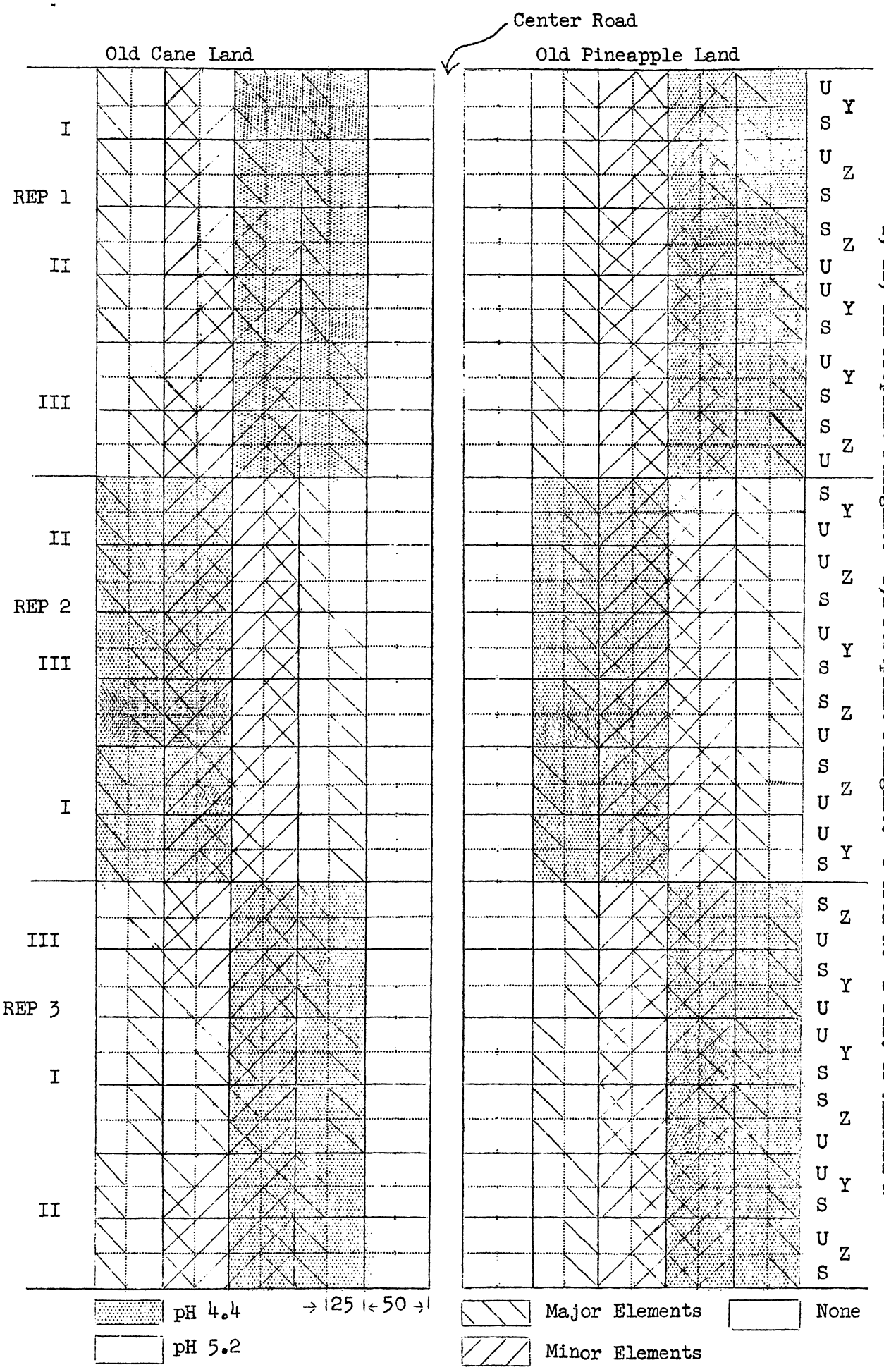
It may be possible to do more pooling of sums of squares than indicated above. Also, there are a number of error mean squares with very few degrees of freedom. Perhaps additional study would indicate that some items could be pooled with these errors to obtain error mean squares with larger numbers of degrees of freedom.

PRI JOINT PROJECT 69
HP Field 4205-06
Layout of Soil pH Plots



PRI JOINT PROJECT 69
HP Field 4205-06
Layout of Minor Element Plots




Center Road
Old Cane Land
Old Pineapple Land
REP 1
REP 2
REP 3
I
II
III
U S U S S U U S U S U S
Y Z Z Z Y Y Z Y Z Z Y Z
S U U S U S S U U S S U
Y Z Y Z Z Y Z Y Z Z Y Z
I, II, III-Preplant Fumigant. Y,Z-Postplant Fumigant. U-Urea N. S-Sul. of Ammonia N
pH 4.4
pH 5.2
→125 ←50 →
Major Elements
Minor Elements
None